# NUGLEAR SCIENCE and ENGINEERING

THE RESEARCH JOURNAL OF THE AMERICAN NUCLEAR SOCIETY

#### ANS OFFICERS

Vincent S. Boyer president

Joseph R. Dietrich vice president/president elect

Harry Lawroski treasurer

Raymond D. Maxson assistant treasurer

Octave J. Du Temple executive director

#### **ANS PUBLICATIONS STAFF**

Norman H. Jacobson publications manager

Joann Hollensteiner editorial coordinator

Nancy Zacha Godlewski copy editor

Diane R. Wojciechowski copy editor

Siegfried H. Krapp production manager

#### COMPOSITION

Beljan, Dexter, Michigan 48130

DIXON CALLIHAN, Editor

MELVIN L. TOBIAS, Associate Editor

MARGE WILLIAMS, Administrative Assistant

Union Carbide Corporation Nuclear Division Oak Ridge, Tennessee 37830

KARL WIRTZ, Associate Editor, Europe

ANTON BAYER, Editorial Assistant

Kernforschungszentrum Karlsruhe D-7500 Karlsruhe Postfach 3640 Germany

#### **Editorial Advisory Committee**

Manson Benedict E. Richard Cohen E. C. Creutz Frank G. Dawson A. F. Henry
A. A. Johnson
C. H. Millar

Frank G. Dawson L. W. Nordheim D. H. Gurinsky Hugh C. Paxton

Fred W. Thalgott

# Volume 61 September, October, November, December 1976

NUCLEAR SCIENCE AND ENGINEERING is published monthly by the American Nuclear Society, Inc., with executive and business offices at 244 East Ogden Avenue, Hinsdale, Illinois 60521 — telephone 312/325-1991. The subscription rate is \$50 per volume or \$132 for three volumes per calendar year; single copies are \$18 (special issues slightly higher). Microfiche subscriptions are also available at same rates. Address subscription order to the publisher. (Back issues of Volumes 1-17 are available from Academic Press, 111 Fifth

Avenue, New York, New York 10003.) Second-class postage is paid at Hinsdale, Illinois, and at additional mailing offices. Printed in Danville, Illinois 61832, by Interstate Printers and Publishers, Inc. Copyright © 1976 by the American Nuclear Society, Inc. Inquiries about the distribution and delivery of NUCLEAR SCIENCE AND ENGINEER-ING and requests for changes of address should be directed to the American Nuclear Society. Allow 6 weeks for a change to become effective.



Copyright © 1976 by American Nuclear Society, Inc., Hinsdale, Illinois 60521

VOLUME 61, NUMBER 1, SEPTEMBER 1976

## **TECHNICAL PAPERS**

1	Numerical Calculation of Two-Phase Flows	John R. Travis, Francis H. Harlow, Anthony A. Amsden
11	Models for Calculating the Effects of Isotopic Exchange, Radioactive Decay, and Recycle in Removing Iodine from Gas and Liquid Streams	Wallace Davis, Jr.
21	Radiation-Damage Calculations: Primary Knock-On Atom Spectra, Displacement Rates, and Gas Production Rates	T. A. Gabriel, J. D. Amburgey, N. M. Greene
33	Neutron Spectrum from a Uranium-235 Sphere Bombarded by 14-MeV Neutrons	C. E. Ragan III, G. F. Auchampaugh, A. Hemmendinger, M. G. Silbert
40	Cross Sections for the Production of 8- to 20-MeV Photons	G. Longo, F. Saporetti
53	Reaction Rates in a Uranium Pile Surrounding a 14-MeV Neutron Source: Calculations of the Weale Experiment	R. C. Haight, J. D. Lee, J. A. Maniscalco
60	The Kinetics of a Coupled Two-Core Nuclear Reactor	Felix C. Difilippo, Ricardo M. Waldman
72	Neutron Transport in Two Dissimilar Media with Anisotropic Scattering	A. R. Burkart, Y. Ishiguro, C. E. Siewert
78	Thermal-Neutron Transport Processes in H <sub>2</sub> O-D <sub>2</sub> O Mixtures in the Temperature Range 253 to 21 K: The Possible Use of These Moderators as Cold-Neutron Sources	G. S. Gangwani, S. P. Tewari, L. S. Kothari
90	The Application of Neutron Transport Codes to the Transport of Neutrals in Plasmas	J. H. Marable, E. M. Oblow
98	Analysis of the Coarse-Mesh Rebalancing Effect on Chebyshev Polynomial Iterations	S. Nakamura

(Continued)

VOLUME 61, NUMBER 1, SEPTEMBER 1976

## (Continued)

123

#### **TECHNICAL NOTES**

107	Mass Transfer in the Contamination of Isothermal Steel Surfaces	D. H. Lister
112	A Low Reynolds Number Bundle-Size Effect for Wire- Wrapped Liquid-Metal Fast Breeder Reactor Assemblies	Ehsan U. Khan
116	The Energy Dependence of the Neutron Absorption and Fission Cross Sections of Uranium-235 and Plutonium-239 Below 1 eV and the Wescott g Factors	R. Gwin
117	A Two-Dimensional Time-Dependent Neutron Transport Calculation Using One-Dimensional Equations	Michael Boring, W. H. Roach
	BOOK REVIEWS	
119	Annual Review of Nuclear Science, Vol. 25, E. Segré (Ed.)	William G. Pollard
120	Symposium on Cooling Tower Environment—1974	T. Shapiro
121	Energy: Historical Development of the Concept, R. Bruce Lindsay (Ed.)	E. Scott Barr

ANNOUNCEMENT OF CURRENT PUBLICATIONS

(Continued)

VOLUME 61, NUMBER 2, OCTOBER 1976

## TECHNICAL PAPERS

127	A Coarse-Mesh Correction of the Finite Difference Method for Neutron Diffusion Calculations	Yasuyoshi Kato, Toshikazu Takeda, Seiichi Takeda
142	Exact Solutions of the Neutron Slowing Down Equation	Trine-Yie Dawn, Chio-Min Yang
159	A Discrete Energy Formulation of Neutron Transport Theory Applied to Solving the Discrete Ordinates Equation	J. Ching, E. M. Oblow, H. Goldstein
170	Perturbation Theory and Importance Functions in Integral Transport Formulations	E. Greenspan
181	The Representation of Light-Water Reflectors by Boundary Conditions	P. C. Kalambokas, A. F. Henry
195	External Bremsstrahlung Generated by Yttrium-91 and Thallium-204 Beta Rays	K. V. N. Sarma, K. Narasimha Murty, V. V. V. Subrahmanyam
201	Calculations of the Neutron Emission Spectra from Materials Bombarded with 14-MeV Neutrons	L. F. Hansen, S. M. Grimes, R. J. Howerton, J. D. Anderson
212	The Transmutation of Strontium-90 and Cesium-137 in a High-Flux Fast Reactor with a Thermalized Central Region	M. Taube
222	Postaccident Heat Removal—Part I: Heat Transfer Within an Internally Heated, Nonboiling Liquid Layer	Louis Baker, Jr., Richard E. Faw, Francis A. Kulacki
231	Postaccident Heat Removal—Part II: Heat Transfer from an Internally Heated Liquid to a Melting Solid	Richard E. Faw, Louis Baker, Jr.
239	Solution of the Fuel Burnup Control Problem with a Controlling Neutron Equation and Walsh Functions	Ryuji Koga
250	On the Dynamics of Transition Region Flow Boiling	W. C. Peterson, M. G. Zaalouk, S. İ. Güçeri

(Continued)

VOLUME 61, NUMBER 2, OCTOBER 1976

(Continued)

## **TECHNICAL NOTES**

258	A Groupwise Rebalancing Technique for Integral Transport Problems	Hsiang-Shou Cheng
261	Two-Dimensional Calculation of a Pulse Propagation Experiment	J. M. A. Christens, P. B. Parks, N. J. Diaz
267	Cross Section for the ${}^{9}\text{Be}(n,t_1)^{7}\text{Li Reaction Between}$ 13.3 and 15 MeV	F. S. Dietrich, L. F. Hansen, R. P. Koopman
269	Geometrical Efficiency Equation for Proton Recoil Telescopes	G. E. Hansen, R. K. Smith, G. G. Simons
276	Nonlinear Dynamics of a Pressurized Water Reactor Core	R. J. Onega, K. E. Karcher
282	Laminar-Flow Pressure Drop in Symmetrical Finite Rod Bundles	John P. Zarling
	LETTER TO THE EDITOR	
286	Comments on the Probability Table Method	M. N. Nikolaev
	COMPUTER CODE ABSTRACT	
288	CYLTRAN	J. A. Halbleib, Sr., W. H. Vandervender
	BOOK REVIEWS	
290	Thermodynamics of Linear Transport Processes, Marjan Ribaric	Edward Larsen
291	The Equations of Radiation Hydrodynamics, G. C. Pomraning	Jeffery Lewins

#### ANNOUNCEMENT OF CURRENT PUBLICATIONS

292

(Continued)

VOLUME 61, NUMBER 3, NOVEMBER 1976

#### **TECHNICAL PAPERS**

297	Two-Phase Pressure Drop Across Abrupt Area Changes in Oscillatory Flow	J. Weisman, T. Ake, R. Knott
310	Transient Freezing of a Flowing Ceramic Fuel in a Steel Channel	Michael Epstein, Michael A. Grolmes, Robert E. Henry, Hans K. Fauske
324	Experimental Development of Design Criteria to Limit Liquid Cross-Flow-Induced Vibration in Nuclear Reactor Heat Exchange Equipment	D. J. Gorman
337	Cross Sections for the $Al(n,xn)$ and $Al(n,x\gamma)$ Reactions Between 1 and 20 MeV	G. L. Morgan, F. G. Perey
346	Neutron Capture Cross Section of Cobalt-59 in the Energy Range 2.5 to 1000 keV	R. R. Spencer, R. L. Macklin
356	Neutron Absorption Cross Section of Americium-241	L. W. Weston, J. H. Todd
366	Light Charged Particles and Fission Elements from Californium-252 Fission	Charles A. Bolig, Jr., R. R. Roy
370	Critical Experiments with Low-Moderated Homogeneous Mixtures of Plutonium and Uranium Oxides Containing 8, 15, and 30 wt% Plutonium	S. R. Bierman, E. D. Clayton
377	A Simple Approximate Treatment of Neutron Inelastic Scattering in a Fast Reactor Assembly	Yasunori Yamamura
388	Synthesis of an Elementary Function for the Spatially Dependent Neutron Slowing Down Distribution in Hydrogen	Harvey J. Amster, K. Cheuk Chan
399	Stability Analysis of Spatially Dependent Nonlinear Reactor Systems Using a Semigroup Approach	Ronald J. Onega, Lech Mync, John A. Burns
408	A Method of Characteristics and Other Improvements in Solution Methods for the Transport Equation	Bengt G. Carlson

(Continued)

#### VOLUME 61, NUMBER 3, NOVEMBER 1976

## (Continued)

446

#### **TECHNICAL NOTES**

426	Observation of a Difference in Yields of Delayed Neutron Emitters from $\rm U_3O_8$ and $\rm UO_2$	H. R. Lukens, R. L. Bramblet
428	Critical Experiments and the 2200 m/sec Neutron Parameters	R. Gwin
431	Acceleration of the Convergence of the Integral Transform Method	V. C. Boffi, V. G. Molinari, G. Spiga
434	Generalized Exact Spatially Dependent Neutron Slowing Down Distribution Near Source Lethargy	K. Cheuk Chan, Harvey J. Amster
437	Control Algorithms in a Coarse-Mesh Rebalance Framework	M. V. Gregory, H. C. Honeck

ANNOUNCEMENT OF CURRENT PUBLICATIONS

VOLUME 61, NUMBER 4, DECEMBER 1976

#### **TECHNICAL PAPERS**

451	An Early-Time Analysis of Space-Dependent Nuclear Reactor Transients	S. L. Paveri-Fontana, P. L. Chambré
466	Reactor-Fuel-Independent Reactivity Determinations	S. Pearlstein
471	Measurement of the Ratio of Fission to Capture Neutron Cross Sections in Uranium-235 in the 200-eV to 15-keV Energy Range	H. Bluhm, C. S. Yen
477	Fission Cross Section of Neptunium-237 from 3 eV to 2 MeV	S. Plattard, J. Blons, D. Paya
496	The ENDF/B-IV Representation of the Uranium-238 Total Neutron Cross Section in the Resolved Resonance Energy Region	G. de Saussure, D. K. Olsen, R. B. Perez
507	Measurement of the Angular Neutron Energy Spectra Originating from a 14-MeV Neutron Source in Liquid Air	K. Clausen, B. Bröcker, P. Schneider-Kühnle, M. Weinert
521	Differential Elastic and Inelastic Scattering of 9- to 15-MeV Neutrons from Carbon	D. W. Glasgow, F. O. Purser, H. Hogue, J. C. Clement, K. Stelzer, G. Mack, J. R. Boyce, D. H. Epperson, S. G. Buccino, P. W. Lisowski, S. G. Glendinning, E. G. Bilpuch, H. W. Newson, C. R. Gould
	TECHNICAL NOTES	
534	Spherical Harmonics Approximations of Neutron Transport	A. Demény, K. M. Dede, K. Erdei
536	A Numerical Method for Solving the Integral Equation of Neutron Transport: III	Robert W. Tsai, Sudarshan K. Loyalka
540	Measurement of Cross Sections for the $^7 \text{Li}(n,n'\gamma)^7 \text{Li}$ Reaction from 0.57 to 4 MeV	Donald L. Smith
543	Rational Approximations for Cross-Section Space- Shielding in Doubly Heterogeneous Systems	M. G. Stamatelatos

(Continued)

VOLUME 61, NUMBER 4, DECEMBER 1976

549	Basic Collapse Criteria for Boiling Reactor-Fuel-Steel Paul B. Abramson Mixtures
553	CORRIGENDUM
554	ANNOUNCEMENT OF CURRENT PUBLICATIONS
558	VOLUME 61 AUTHOR AND SUBJECT INDEXES



